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EFFECT OF SOME DETERGENTS, HUMATE, AND COMPOSITION OF
SEEDBED ON CROP OF TOMATO PLANTS
IN A HYDROPONIC CULTURE

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16. Abstract It has been established that single detergent doses distinctly stimulate vegetative development of plants in the initial stage when humates are available. When detergents are applied every four weeks in a hydroponic culture, in which the seedbed does not contain active humates, the crop is reduced by 50%. This adverse effect does not occur when the seedbed is a mixture of brown coal and peat.			
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EFFECT OF SOME DETERGENTS, HUMATE, AND COMPOSITION OF
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Introduction

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Guminski et al. (1972) discovered a stimulation of tomato seedling growth when a suitable low detergent dose was added to media in water cultures. This stimulation was accompanied by increased nitrogen, phosphorus, lime, magnesium and iron accumulation with a simultaneous decrease in potassium accumulation. Higher concentrations inhibited growth of the plants. This study discusses the relatively sparse literature dealing with the effects of detergents on a plant organism.

In horticulture, detergents are used as agents facilitating contact of pesticides with leaves which are sprayed with various chemical used to protect plants. So far, detergents have not been considered as possible growth stimulators.

In view of the possible practical application of the results obtained by Guminski et al. (1972), the objective in this study is to investigate the effects of optimal detergent doses (according to the aforementioned authors) on the growth of seedlings and the tomato crop in hydroponic cultures.

Material and Methods

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The experiments were based on transplanting one short-lived and one longer lasting hydroponic culture. In the first case the plant material used was tomato seedlings of the "Zelandia" variety and in the second case, tomatoes of

*Numbers in the margin indicate pagination in the foreign text.

the "Potentat" variety.

One liter capacity jars protected from penetration of light into the medium were used in the short-term experiment. Five centimeter deep plastic bags with holes in the bottom (10 mm diameter holes) were placed on the jars. These bags were filled with a peat-cinder hydroponic seedbed in which the plants were planted. Three seedlings were grown in each jar.

Five liter capacity stoneware jars on which 7 cm deep ceramic dishes with holes in the bottom were placed were used in experiments carried out with tomatoes until the harvest of the vegetable crop. The diameter of each hole was about 10 cm. These dishes were filled with the hydroponic seedbed in which the plants were planted, one plant in each dish.

The chemical composition of the culture medium (in grams per 1 liter tapwater) was as follows:

superphosphate (20% P_2O_5)	0.8
$Ca(NO_3)_2 \cdot 4H_2O$	0.7
KNO_3	0.7
$MgSO_4 \cdot 7H_2O$	0.3
$Fe_2(SO_4)_3 \cdot nH_2O$	0.1

In addition: H_3BO_3 , $ZnSO_4 \cdot 7H_2O$, $MnSO_4 \cdot 7H_2O$, $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$, 0.6 mg each and $CuSO_4 \cdot 5H_2O$ in the amount 3 mg per liter culture medium. The culture medium reaction was obtained at pH = 6.5, which was controlled during vegetation of plants every 10 days. Whenever necessary the solution was alkalized using NaOH or acidified using H_2SO_4 .

Mixtures of peat and brown coal, peat and cinders, or sponges and cinders were alternately used as seedbeds.

The Wroclaw "Pollena" Agricultural Chemistry Plant supplied us with preparations whose active compounds were as follows:

1. SDBS - sodium dodecylbenzenesulfonate
2. ESLS - ethoxy sodium lauryl sulfonate
3. TDBS - triethylamine dodecylbenzenesulfonate
4. M = (SDBS + SAS) - sodium dodecylbenzenesulfonate + sodium alkyl sulfate

A single detergent dose was 0.5 mg active substance per 207 liter culture medium.

Humate was obtained by nitration of brown coal from Sieniawa with a mixture of nitrogen and sulfuric acid, followed by neutralization with ammonia water according to the method elaborated by D. Augustyn and H. Martyniuk.¹ In text experiments which consisted of transplanting short-lived classical aqueous cultures with an aerated and stagnant medium (Guminski, Sulej, 1967, and Guminska et al., 1968), it was established that a humate preparation obtained from brown coal was in every respect as effective as humate obtained by the stereo-type method from leaf moulds.

The plants were grown in greenhouses under natural lighting.

Description of Individual Experiments and Their Results

1. Effects of Four Detergents, Humate, and EDTA on Growth of Tomato Seedlings

Tomato seeds which were sprouted in sun-dried sand were watered with tapwater. Seedlings were planted in 1-liter capacity jars with the culture medium (3 per jar) by placing the plants in the cinder-tuft bedding. The corresponding

¹We obtained the brown coal preparation from Assistant Professor Dr. D. Augustyn, for which we express our gratitude on this occasion.

control groups used were: 1) cultures grown in a medium without nutrient supplements; 2) with a humate supplement; and 3) with a versenate supplement. The experimental design is shown in Table 1. Each object (combination) had six duplicates (six jars, each with three seedlings). The plants grew for 19 days in September. The culture media were neither mixed nor aerated throughout the entire duration of the experiment. They were also not exchanged or replenished. The dry bulk of sprouts and roots was determined after 19 days of vegetation. Quantitative results are presented in Table 1. Detergents SDBS and ESL3 caused a marked decrease in the weight of the dry bulk of sprouts, TDBS caused a slight increase in its weight, and M had no significant effect. The humate reduced the dry bulk, while versenate increased the dry bulk considerably. A humate supplement in a culture medium containing SDBS greatly reduced the dry bulk of sprouts, whereas in combination with the remaining detergents, it had the opposite effect, namely it caused a considerable increase in the dry bulk, compared both with control plants and plants treated with appropriate detergents. In particular, in the TDBS + humate combination, the effect was unusually beneficial; the increase in the dry bulk was about 100% greater compared to plants growing in culture media to which the substances had not been added, hence compared to the basic control group. /208

The versenate supplement in culture media containing SDBS reduced the dry bulk (similarly as humate, but not as much). In the presence of ESL3 and M versenate caused a greater increase in the dry bulk, and in combination with TDBS, it had no significant effect compared to the effect of the detergent alone. In the case of substance M, the effect of the detergent combined with versenate was beneficial compared with plants in the basic control group (without supplements in a culture medium).

TABLE 1. EFFECT OF DETERGENTS, HUMATES, AND EDTA ON
GROWTH OF TOMATO SEEDLINGS. EXPERIMENT:
4 SEPTEMBER - 23 SEPTEMBER, 1969.

Experimental Series	Sprouts (mg)	Roots (mg)
Culture medium without nutrients	483.0	72.0
Culture medium + humate	410.0	72.5
Culture medium + EDTA	622.5	58.3
SDBS	421.0	58.3
SDBS + humate	265.0	46.0
SDBS + EDTA	316.0	50.0
ESLS	390.0	60.3
ESLS + humate	543.3	56.6
ESLS + EDTA	500.0	52.5
TDBS	525.0	57.5
TDBS + humate	985.0	68.0
TDBS + EDTA	500.0	45.3
M • (SDBS + SAS)	500.0	48.0
M + humate	574.2	53.3
M + EDTA	822.5	58.0
Confidence interval $p = 0.05$	40.3	10.9

These results were not truly reflected in the dry bulk of plant roots. All substances used except humate alone or TDBS in combination with humate where no significant effects /209 were ascertained caused a decrease in the dry bulk of roots compared with roots of plants in the basic control group. The greatest decrease was ascertained in the case when SDBS was combined with humate and TDBS with versenate and during application of detergent M alone.

2. Determination of Optimal Tomato Fertilization and Effect of Preparation Made from Brown Coal from the Sieniawa Mine on Tomato Crop

A vegetation experiment using various doses of mineral salts (full nutrient medium) was carried out to determine optimal fertilization for tomatoes in the hydroponic culture. The difference consisted in adding an appropriate concentration of the nutrient solution every 10 days. The effect of five salt doses was compared, namely 25, 50, 75, 100 and 125 g throughout the entire vegetation period, while maintaining the same liquid level (about 4.5 l). At the same time the effectiveness of humate from Sieniawa brown coal was investigated in relation to different quantities of mineral salts. A hydroponic seedbed consisting of cinders with sponge cut into cubes (in the voluminal ratio 1:1) was used in order not to obscure the effects of humates added to the nutrient medium.

Plant vegetation lasted from the beginning of April until the end of May. Inflorescence was hormonized with sodium salt of 3-indolylacetic acid.

Observation demonstrated that plants in nutrient media with humate were characterized by more intense verdure.

Quantitative results obtained from the experiments pertain to the weight of the vegetables taking into account the total crop, the commercial crop, and the early yields. These results indicate (Table 2) that the optimal fertilization dose calculated per plant and the entire vegetation period turned out to be: a) 75 g without humate, b) 50 g with humate. However these differences remained within the error range. Markedly lower yields were obtained by using the lowest, 25 g dose, 100 g dose with humate supplements, and by using higher doses. Adding a humate to all these supplements tended to have a

beneficial influence on the tomato crop, whereas at the highest doses, the yield was markedly reduced in the presence of humate. In addition, the beneficial effect of humate on early yield increased commensurately with the intensity of fertilization.

TABLE 2. DETERMINATION OF OPTIMAL TOMATO FERTILIZATION /210
AND EFFECT OF HUMATE FROM BROWN COAL FROM
SIENIAWA MINE ON TOMATO CROP. EXPERIMENT:
7 APRIL - 30 JULY, 1970. TEMP. 15-30°C

Amount of Fertilizer, g	Crop		Early Crop in June, g	% Increase in Early Crop
	Commercial, g	Total, g		
25	696	696	23.3	100
25 + hum.	750	759	28.3	121
50	785	800	36.6	100
50 + hum.	828	858	68.3	186
75	815	834	38.3	100
75 + hum.	780	818	77.5	214
100	761	801	16.6	100
100 + hum.	546	567	47.5	286
125	616	633	23.3	100
125 + hum.	396	416	89.1	360

Confidence
interval
p = 0.05

159

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3. Effect of Detergent M on Fructification of Tomatoes /209 in Relation to Type of Seedbed and Frequency of Its Use

An experiment with tomato seedlings lasting several months was initiated in March of the following year. The seedlings were planted in hydroponic pots using three types of seedbed, namely: peat and cinders, a mixture of peat and brown coal from Sieniawa, and cut sponge with cinders. Three combinations /210 were used with all three seedbeds: 1) control cultures without a detergent; 2) detergent M added once to nutrient medium in the amount 0.5 mg per liter; and 3) detergent M added in the

same amount every 4 weeks. The amount of fertilizer used, based on the results of the experiment described earlier, was 75 g nutrient salts for the entire vegetation period. This amount was divided appropriately, and the calculated portion was added every 10 days. In the initial period before the roots reached the nutrient medium, the seedbed was sprinkled with the nutrient medium pumped from the pot in which the plant grew. When the roots reached the nutrient solution in the pot, the seedbed was only watered with tapwater. When necessary, the nutrient solution in the pot was replenished with tapwater to a steady level; however, the aerated space between the seedbed and nutrient medium was gradually increased commensurately with the growth of the plants (initially from 2 to 5 cm after several weeks of vegetation). The efflorescence was hormonized using the "Betokson" preparation. Cultivation was conducted from March 10 to July 30.

Observations made during experimental plant vegetation /211 have shown that towards the end of March all plants in objects (combinations) with detergents were distinctly taller and had thicker sprouts than plants in control objects. On the other hand, in May these differences disappeared, and the appearance of the control plants was even better than the appearance of plants treated with detergents. First efflorescence appeared in plants from cultures with a peat-coal seedbed, while differences resulting from proportioning of detergents were not detected. The first vegetables also appeared on plants grown in a peat-coal seedbed. It was also noticed that in cultures with a peat-coal seedbed, the differences in the appearance of control plants and plants treated with detergents were obliterated.

The total vegetable crop presented in Table 3 indicates that the effect of the detergent depends on the type of seedbed.

TABLE 3. EFFECT OF M = (SDBS + SAS) DETERGENT ON TOMATO /212
FRUCTIFICATION IN RELATION TO TYPE OF SEEDBED
AND FREQUENCY OF ITS USE. TOTAL YIELD (g).
EXPERIMENT: 10 MARCH - 30 JULY, 1971. TEMP:
 $\pm 20^{\circ}\text{C}$

Detergent	Seedbed			Mean for Detergent
	Cinder + Tuft	Brown Coal + Tuft	Cinder + Sponge	
Without detergent (control)	1410	1227	1283	1306
Detergent applied once	927	1220	1106	1085
Detergent applied every 4 weeks	1013	1297	655	988
Mean for seedbed	1117	1248	1015	

Confidence interval ($p = 0.05$) for combination = 312

Confidence interval ($p = 0.05$) for detergents = 180.7

Confidence interval ($p = 0.05$) for seedbeds = 180.7

A mixture of tuft with brown coal withstood the adverse effects /211
of the detergent, whereas in peat-cinder and sponge-cinder seed-
beds, the detergent lowered the yield. In the sponge and cinder
mixture this effect was much more pronounced when the detergent
was applied every 4 weeks than in a single application.

Discussion of Results

The experiments described above confirmed the results
obtained by Guminski et al. (1972) in the sense that the doses
of two detergents recommended by them, namely triethylamine

dodecylbenzenesulfonate (TDBS) and a mixture of sodium dodecylbenzenesulfonate with sodium alkyl sulfate (M) caused, after single application, faster growth of tomatoes in the initial vegetation period. This beneficial effect was considerably enhanced under the influence of humate. Beneficial growth effect was also obtained in the presence of ethoxy sodium lauryl sulfonate (ESLS) applied together with humate, even though this detergent alone distinctly inhibited growth. On the other hand, humate combined with sodium dodecylbenzenesulfonate (SDBS) had a decidedly adverse effect, since inhibition of growth was much greater than during application of the detergent alone.

Comparison of the effectiveness of humate and versenate indicates that, although not identical, the effect of both compounds was basically similar. Because both these substances, which differ so much in their chemical structure, have the common property that they form complex bonds with bi- and multivalent cations, they suggest the assumption that their similar effectiveness, known from experiments conducted in classical water cultures (Guminski et al., 1965), is also based on the formation of this type of complex compounds when they interact with detergents.

Although a single application may initially accelerate the /212 growth of seedlings, repeated applications of small detergent doses in longer-lasting cultures turned out to be dangerous. The observation that the harmful effect of the detergent applied several times was more pronounced in a seedbed consisting of sponge and cinder, less pronounced in the case of a peat-cinder seedbed, and did not occur at all in a peat-brown coal seedbed is interesting. It suggests the assumption that the humus substances contained in the peat and brown coal in the seedbed prevented the harmful action of the accumulating detergent.

Here, one should mention that the high yield of brown coal as /213 a raw material in the extraction of humates has been established in preceding studies.

The beneficial effect of the appropriate detergent used once on the initial development of tomatoes can be explained by the great accumulation of nitrogen, phosphorus, lime, magnesium and iron as demonstrated by Guminski et al. (1972). This hypothesis is supported by the results of Blanc's studies (1973), indicating low absorption of phosphorus and magnesium compared with other macrocomponents in the initial development period of tomatoes. The adverse effect of small quantities of detergent can be linked to the corresponding observations made by Farr and Norman (1964) and Guminski et al. (1972) pertaining to reduced potassium accumulation under the effect of these substances. Considering the fact that humus compounds facilitate the absorption of iron (Olsen, 1930, 1935, De Kock, 1955; Guminski et al., 1965) and phosphorus (Chaminade, 1952; Chaminade and Blanchet, 1953; Wojciechowski, 1948), correct the P/Fe ratio in plants, tend to impede the absorption of lime (Jurajda, 1973; Skinder, 1970) and cause an increase in the K/Ca ratio (Catsky, 1958), the assumption can be made that the beneficial effect of detergents and humate is based on a coordination of accumulated mineral components in hydroponic tomato cultures.

Conclusions

1. Faster growth of tomato seedlings in hydroponic cultures can be obtained by using a single 0.5 mg triethylamine dodecylbenzenesulfonate dose or a mixture of dodecylbenzenesulfonate and sodium alkyl sulfate with humate in the amount 100 mg per liter culture medium.
2. A humate supplement in the culture medium, especially

when accompanied by intense mineral nourishment, causes a substantial increase in the early tomato crop.

3. A mixture of tuft and brown coal used as a seedbed prevents the adverse effects of detergents contained in the culture medium.

Summary

The beneficial action of detergents interacting with humates on initial tomato growth has been ascertained in a short-term hydroponic experiment.

The optimal quantity of fertilizer for one tomato throughout the entire vegetation period was determined in a second experiment conducted until the crop. This quantity was 25 g in a combination without humate and 50 g in the presence of /214 humate. However, these results are within the error range; a marked decrease in the crop occurred at a 25 g dose, 100 g dose and higher doses. The humate supplement in the culture medium caused an increase in the early tomato crop, especially in the presence of intense mineral nourishment.

The third experiment in which the SDBS + SAS detergent was applied in the tomato culture once and every 4 weeks to three types of seedbeds demonstrated that the detergent reduces the tomato crop by 50% when it is used every 4 weeks. This effect occurs in tomatoes grown on a cinder-sponge seedbed, to a lesser extent on a cinder-**peat** seedbed, while the adverse effect of the detergent was cancelled in a brown coal and **peat** seedbed.

REFERENCES

1. Blanc, D., "Influence of hydrous regimen on production and development of greenhouse tomatoes without soil in water and mineral elements," Third International Congress on Soilless Culture, Sassari, 1973, pp. 227-235.
2. Catsky, J., "The effects of oxyhumates on mineral plant nutrition," Ceskoslovenska Biologie 7, 2, 111-122 (1958).
3. Chaminade, R., "Farms using phosphorus in soil. Nature and role of phosphorohumic compounds," Ann. Agr. 1.
4. Chaminade, R., "Influence of humus on nutrient minerals of vegetables," Ann. Agr. 3, 4, 570 (1952).
5. Chaminade, R. and R. Blanchet, "Simulating action of humus on development and mineral nutrition of vegetables in soil," C.R.Ac.Sc. 236, 1, 119 (1953).
6. DeKock, F.C., "Influence of humic acids on plant growth," Science 121, 473 (1955).
7. Guminska, Z., D. Augustyn, M. Graczowna, and J. Sulej, "Studies of biological value of humate extracts from brown coal," Wegiel Brunatny, Gornictwo Odkrywkowe 10, 4, 549-554 (1968).
8. Guminska, Z., M. Gracz-Nalepka, B. Kukasiewicz, M. Koniarek, 215 M. Osmelak and B. Paluch, "Effects of sodium humate from brown coal on plant development," Acta Agrobotanica 24, 2, 143-170 (1971).
9. Guminski, S, Z. Guminska and J. Sulej, "Effect of humate, agar-agar and EDTA on the development of tomato seedlings in aerated and non aerated water cultures," J. Exp. Bot. 16, 151 (1965).
10. Guminski, S and J. Sulej, "The relation between certain physicochemical properties of humate components and their biological activity," Act. Soc. Bot. Pol. 34, 109 (1967).

11. Gumiński, S., E. Tatkowska, A. Suder-Moraw and S. Wilczkowski, "Effect of some detergents on biomass increment and accumulation of mineral components in *Solanum lycopersicum* and *Scenedesmus quadricauda*," Acta Soc. Bot. Pol. 41, 2, 253-264 (1972).
12. Jurajda, K, "Effect of sodium humate in relation to various quantities of lime and iron on the increase in the number of cells and dry bulk in *Scenedesmus quadricauda* and *Gonium pectorale*," Acta Soc. Bot. Pol. 43, 4, 519-530 (1974).
13. Olsen, C., "On the influence of humus substances on the growth of green plants in water culture," C.R.Labor. Carlsberg. 18, 1-16 (1930).
14. Olsen, C., "Iron absorption and chlorosis in green plants," C.R. Labor. Carlsberg. 21, 15-52 (1935).
15. Parr, J.F. and A.G. Norman, "Effect of nonionic surfactants on root growth and cation uptake," Plant Physiol. 39, 502-507 (1964).
16. Skinder, N., Hamujace dzialanie humianu sodowego na liczeb-
nosc populacji *Oscillatoria sancta* (Kutzing) Goment
[Inhibiting effect of sodium humate on population
size of *Oscillatoria sancta* (Kutzing) Goment] Doctoral
thesis (typed manuscript, Wroclaw University).
17. Wojciechowski, J., Porownawcze badania nad wplywem zelaza
i zwiazkow prochnicznych na rosliny [Comparative
studies of the effect of iron and humus compounds
on plants] Transactions of the Department of Natural
Science of the Polish Academy of Sciences, Vol. 73,
Part B (series III, Vol. 33).